BASIC ELECTRICITY AND ELECTRONICS

STUDENT HANDOUT NO. 205

SUMMARIES PROGRESS CHECKS FOR MODULES

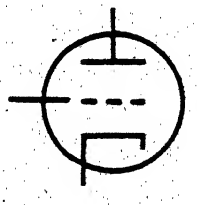
21T LESSONS 1&2

JUNE 1984

SUMMARY
LESSON 1

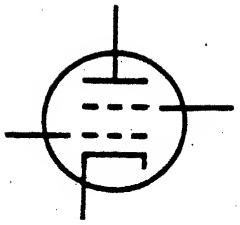
Multi-Element Vacuum Tubes

The diode vacuum tube contains two elements, but vacuum tubes are not restricted to just two elements; tubes that must do more than just rectify need three or more elements. Vacuum tubes (amplifiers) have three, four, five and more elements depending on what the tube is being used for. The most important, from the standpoint of usage, is the triode (Figure 1). Inserting a fine wire mesh or control grid between the cathode and the plate creates the three element tube; the triode. The control grid (like the transistor base) determines the amount of electron flow through the device.



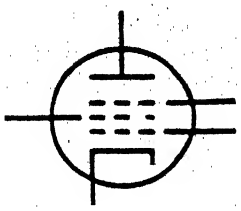
Triode
Figure 1

Triodes are amplifying devices that function like NPN transistors. (NOTE: There is no tube equivalent to the PNP transistor. Current flow in a tube won't go that way.) Unlike the NPN transistor base, the control grid is normally operated at some negative potential. This is necessary because a positive control grid would not only draw current (which in tube amplifiers is bad) but would conduct so many electrons to the plate, that it would always be saturated and could not amplify. The control grid can also be placed at such a high negative potential, that no current will flow through the tube, a condition known as cut-off. The control grid has such a great effect on the triode that it has more control over plate current than does plate voltage, but the triode isn't fault free. It really doesn't work so well at high frequencies. (The rapid changes were more than the triode could handle.) For high frequencies, vacuum tube amplifiers utilize tetrodes and pentodes.



Tetrode
Figure 2

The tetrode (Figure 2) is a four element vacuum tube, with the fourth element inserted between the control grid and the plate. This element is called a screen grid. The screen grid acts as a shield and is normally operated at some positive voltage (typically 90 volts). Due to its shielding effect, the screen grid also has more effect on plate current than does plate voltage. The tetrode can handle the frequency, but it is not linear, which causes distortion in the output when a large input signal is applied. This non-linearity reduces the use of a tetrode as an amplifier. The solution to this problem is the pentode (see Figure 3).

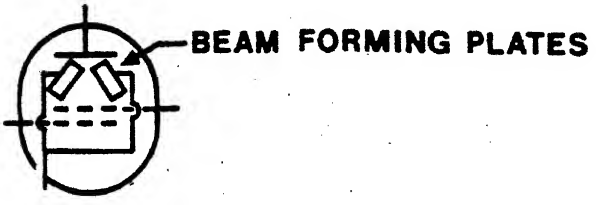


Pentode
Figure 3

The Pentode has a fifth element, placed between the screen grid and the plate. This fifth element is called a Suppressor Grid and it usually operates at the same potential as the cathode. It causes the plate current to rise uniformly with a proportional increase in plate voltage. The suppressor grid also increases the available gain and extends the frequency range beyond that of the tetrode.

Each of the multi-element vacuum tubes can be used in an amplifier circuit (radios, TV's) but they won't deliver the power required to drive a public address system or a radio transmitter. For this we use power tubes; power triodes, beam power tubes and power pentodes. The differences between power tubes and regular multi-element tubes are minimal. The basic differences are in the size of the internal elements. The elements for power tubes are larger.

Schematically, the only difference in presentation is the beam power tube (Figure 4). The beam power tube has all of the elements of a tetrode; plus, just above the screen grid, it has two beam forming plates.



Beam Forming Tube
Figure 4

The function of the plates is to concentrate the electrons into a small area. Functionally, the beam power tube is identical to the power pentode.

Schematically, all components are referred to with letter number combination. Resistors use "R", and capacitors use "C". Vacuum tubes use the letter "V".

AT THIS POINT, YOU MAY TAKE THE LESSON PROGRESS CHECK. IF YOU ANSWER ALL SELF-TEST ITEMS CORRECTLY, PROCEED TO THE NEXT LESSON. IF YOU FEEL THAT YOU HAVE FAILED TO UNDERSTAND ALL, OR MOST, OF THE LESSON, SELECT AND USE ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS (IF APPLICABLE), OR CONSULTATION WITH YOUR LEARNING CENTER INSTRUCTOR, UNTIL YOU CAN ANSWER ALL SELF-TEST ITEMS ON THE PROGRESS CHECK CORRECTLY.

AV RESPONSE SHEET
LESSON I

Multi-Element Vacuum Tubes

1. 1. _____
   2. _____
   3. _____
2. A B C D (CIRCLE ONE)
3. A B (CIRCLE ONE)
4. 1. _____
   2. _____
   3. _____
   4. _____
5. A B C D (CIRCLE ONE)
6. A B C D (CIRCLE ONE)
7. 1. _____
   2. _____
   3. _____
   4. _____
   5. _____
8. A B C D (CIRCLE ONE)
9. A B C D (CIRCLE ONE)

PROGRESS CHECK
LESSON I

Multi-Element Vacuum Tubes

1. A triode vacuum tube consists essentially of a diode with a/an _____ _____ added.

2. Electron flow through the triode is controlled by varying the voltage on the:

   a. plate
   b. control grid
   c. cathode
   d. filament

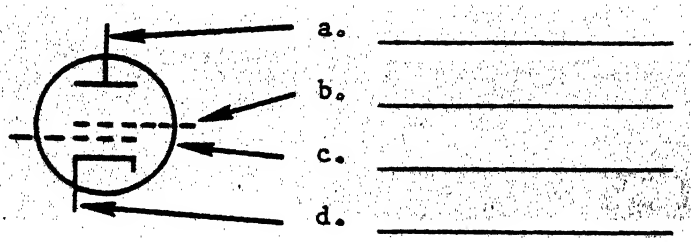
3. Current flow in a triode vacuum tube will be the same as current flow in a/an _____ type transistor.

4. Cutoff will occur in a triode vacuum tube when the control grid becomes (negative/positive) enough.

5. Which of the following statements is most correct?

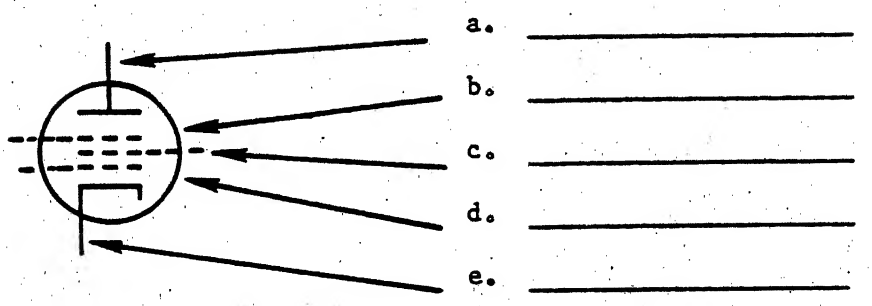
   a. When the control grid potential is negative enough it causes saturation.
   b. When the control grid potential is positive enough it causes saturation.
   c. The cathode is closer to the plate than is the control grid.
   d. The control grid in a triode is the only element controlling plate current.

6. Label the elements of the vacuum tube schematic symbol below.



7. The (plate/screen grid) voltage has the most effect on plate current.

8. Label the elements of the vacuum tube schematic symbol below:



9. What advantage does a pentode have over a tetrode or a triode?

   a. Linear current increase, decreased plate voltage, extended frequency range.
   b. Limited frequency range, greater available gain, increased plate voltage.
   c. Linear current increase, extended frequency range, greater available gain.
   d. Lower power requirements, linear current increases, extended frequency range.

10. The primary difference between power tubes and regular multi-element tubes is:

   a. that they require larger power supplies.
   b. the size of the tube elements.
   c. the size of the tube.
   d. their schematic symbols.

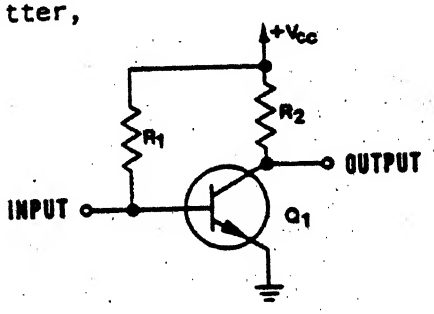
CHECK YOUR RESPONSES TO THIS PROGRESS CHECK WITH THE ANSWER SHEET. IF YOU ANSWER ALL SELF-TEST ITEMS CORRECTLY, PROCEED TO THE NEXT LESSON. IF YOU FEEL YOU HAVE FAILED TO UNDERSTAND ALL, OR MOST, OF THE LESSON, SELECT AND USE ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS (IF APPLICABLE), OR CONSULTATION WITH YOUR LEARNING CENTER INSTRUCTOR, UNTIL YOU CAN ANSWER ALL SELF-TEST ITEMS ON THE PROGRESS CHECK CORRECTLY.

SUMMARY
LESSON 11

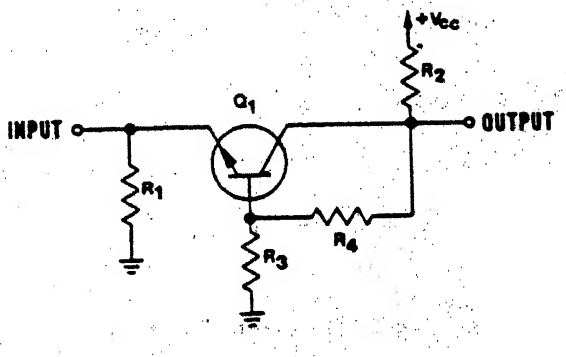
Vacuum Tube Circuit Configurations

In Module Twenty One, Transistor Amplifiers, you were introduced to the three basic amplifier configurations.

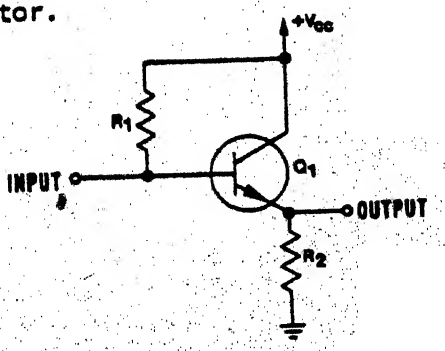
They are the common-emitter,



the common-base,



and the common-collector.



Each circuit has a particular function. Tubes are used in circuits that compare with these simple amplifiers.

The first is the grounded-cathode (see Figure 1). (NOTE: B+ indicates source voltage.)

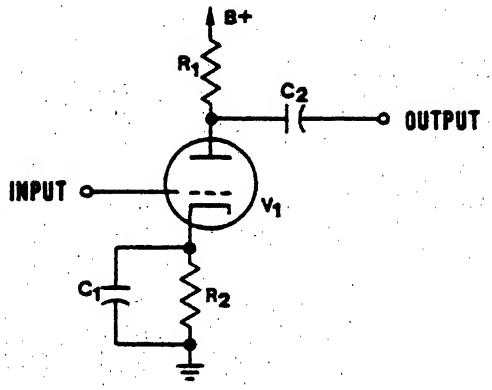


Figure 1

As in the common-emitter amplifier where the input signal was applied to the base, the input signal is now applied to the control grid. The output signal is taken from the plate. This circuit has 180° phase inversion with good voltage and power gain. The grounded-cathode tube amplifier is the most extensively used vacuum tube circuit configuration.

The second circuit configuration is the grounded-grid amplifier (see Figure 2). As in the common-base circuit where the input signal is applied to the emitter,

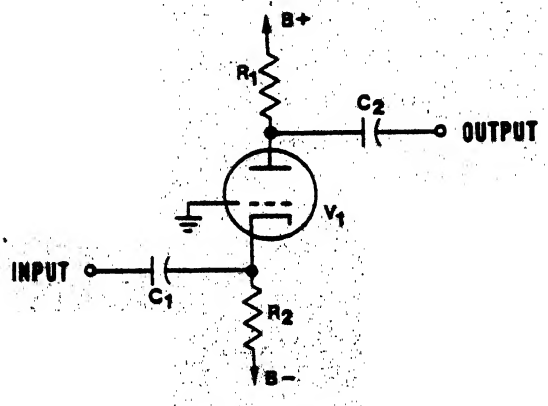


Figure 2

the input is applied to the cathode, and the output is taken from the plate. The grounded-grid amplifier, like the common-base amplifier, has no phase inversion. This circuit configuration is generally used in higher frequency applications. The grounded-grid has a lower power gain than the grounded-cathode but it has a higher voltage gain.

The third type of circuit configuration is the grounded-plate (Figure 5). This circuit is similar to the common-collector circuit. A more common name for this circuit is cathode follower.

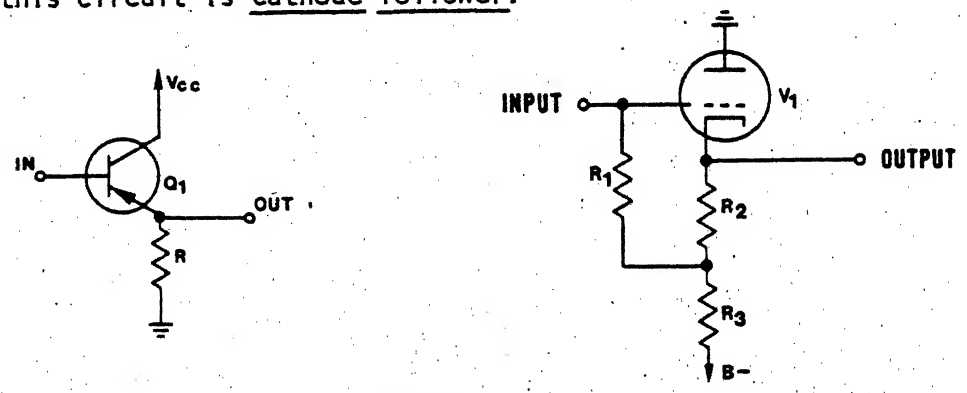


Figure 3

The input is applied to the control grid and the output is taken from the cathode. Cathode followers are used in impedence matching because of their high input impedance and low output impedance. The voltage gain of a cathode follower is less than unity (1), and the power gain is less than that of the grounded-cathode amplifier. Cathode followers have no phase inversion between input and output signals.

The three circuits we just compared were all single-ended. The next circuit is a push-pull tube circuit (Figure 4). As in the transistor circuit, the tube push-pull amplifier will have transformer coupling into and out of the circuit.

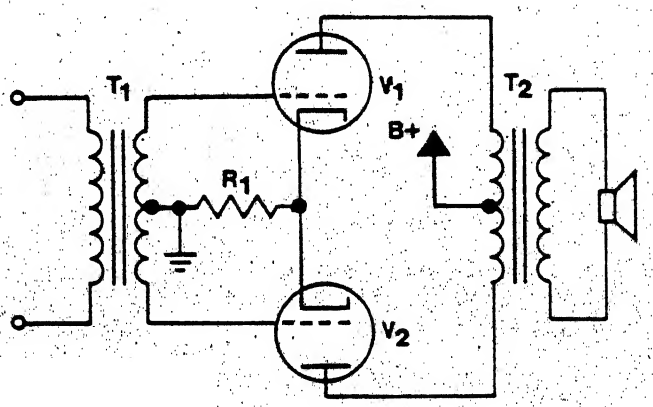
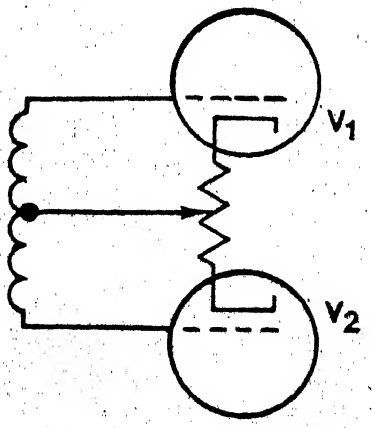


Figure 4

As in the transistor push-pull amplifier, the secondary of the input transformer, T1, provides the matched tubes with two identical signals 180° out of phase. The amplified signal out of one tube is 180° out of phase with the other tube's output, thus providing the push-pull effect across the primary of the output transformer, T2.

Capacitive coupling can also be used for the input. The center-tapped transformer, T1, functions as a phase-splitter. When a signal is applied to the primary, the secondary of T1 provides two identical outputs 180^{c} out of phase. The signals from the input transformer are applied to the control grids of the vacuum tubes in the push-pull stage, one to each tube. If both amplifiers conduct equally, and the input signals to each tube are equal, then the output signals from the plate of each tube will be equal in amplitude. These output signals will also be 180^{o} out of phase, because both of the grounded-cathode tubes will invert their input signals.

If the tubes are not matched, an adjustable resistor will have to be added to the cathode circuitry. The resistor must be adjusted so each tube will amplify the same. This adjustment changes the balance of the bias between one tube and the other.



The output signals from the tubes are applied across the primary of the output transformer, T2. When the current from one tube is increasing, the current from the other tube is decreasing. The push-pull action causes the changes in currents to aid each other so that the output of power from the secondary is much higher.

Summary

In the push-pull circuit you have two inputs, one to each tube, and one large output. The phase-splitter circuit (Figure 5) has one input signal and two output signals. The phase-splitter, therefore, can be used as an input circuit for a push-pull amplifier.

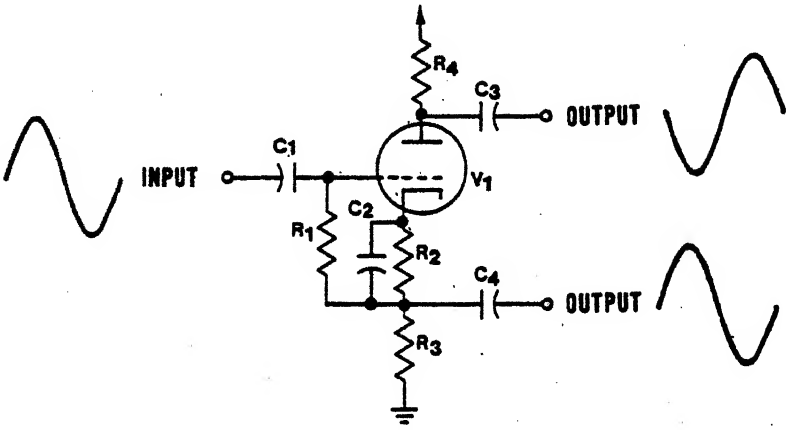


Figure 5

The input sine wave is applied to the control grid of the tube. The output signals, one from the plate and one from the cathode, will be about the same size as the input signal. The cathode signal will be in phase with the input while the plate signal is 180° out of phase with both signals.

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JOB PROGRAM
FOR
LESSON II

PART I

Vacuum Tube Circuit Configurations

DUCTION

ob program will familiarize you with some of the basic vacuum tube .ts and point out the tube circuit similarities to transistor cir-

·e all standard safety precautions. The NIDA 206 Amplifier has a ·oltage power supply located under the bottom cover. DO NOT remove ›ttom cover. There is a switch on the chassis that controls high ;e to the PC board plugs.

ob program will require you to apply high voltage to the PC board. remove the PC board unless the NIDA 206 Amplifier is deenergized. :he amplifier energized, approximately +200 VDC is applied to the ırd in use.

:NCE(S)

›chnical Manual for NIDA 206 Amplifier.

EQUIPMENT AND MATERIALS

1. NIDA 206 Amplifier
2. PC 206-1 Printed Circuit card
3. PC 206-2 Printed Circuit card
4. PC 206-3 Printed Circuit card
5. PC 206-4 Printed Circuit card
6. Vaccum Tubes Types 6C4 and 6AU6 (1 each)
7. Oscilloscope, Dual - Trace
8. Signal Generator
9. 10X probe (1)
10. 1X probe (1)
11. BNC to Phone Jack Cable (1)

PROCEDURE

1. Energize and set up the signal generator for a 1 KHz output. Energize and set up the oscilloscope.

2. Remove only the top cover from the NIDA 206 Amplifier.

NOTE: Perform steps 3 through 8 for PC 206-1. When you have completed step 8, repeat steps 3 through 8 for PC 206-2, then go through the procedure again with PC 206-3. Refer to the NIDA 206 Instruction Manual for schematic drawings.

3. Install a 6C4 tube in the socket on PC Board PC 206-1 (206-2; 206-3) install this PC board in the NIDA 206 Amplifier. Turn the high voltage on.

Caution: When the NIDA 206 Amplifier is energized, there will be +200 VDC at pin (5) of the PC board and various components on the board. Use extreme caution around these points!

4. Using the BNC to Phone Plug Cable, connect the 1 KHz signal generator output to the INPUT jack on the front panel of the amplifier. Connect the 10X probe, to channel 1 of the oscilloscope and to the PC board output. Connect the 1X probe to channel 2 of the oscilloscope and to the PC board input.

5. Plug in and energize the amplifier. Allow approximately 1 minute for tube warmup before proceeding. Set the volume control fully clockwise.

6. Potentiometer R17, located on the chassis to the left of the PC board, is the bias voltage control. Using R17 and the AUDIO OUT or ATTENUATION adjustment on the signal generator, adjust for maximum undistorted output from the PC board.

7. Compare the input amplitude and the output amplitude, and answer the following questions:

a. What is the gain of the amplifier?

PC 206-1 _____
PC 206-2 _____
PC 206-3 _____

b. Does this amplifier invert the signal?

PC 206-1 _____
PC 206-2 _____
PC 206-3 _____

c. What is the transistor circuit equivalent to this circuit?

PC 206-1 common _____
PC 206-2 common _____
PC 206-3 common _____

WARNING

WAIT 30 SECONDS AFTER DEENERGIZING CIRCUIT BEFORE REMOVING CARD TO ALLOW CAPACITORS TO DISCHARGE.

When you have completed Step #7 for one board, deenergize the amplifier, remove the tube and the PC board. Go back to Step #3 and repeat the procedure using the remaining board(s). When you have completed the preceding steps for all three boards, proceed with the rest of the procedures.

8. Ensure the amplifier is deenergized. Insert a 6AU6A tube in the tube socket on PC board PC 206-4. Remove the PC card in the NIDA 206 and install PC 206-4.

9. Connect the 10X Probe to the output of PC 206-4.

10. Refer to the schematic and complete the following statements

a. The 6AU6A tube is a

(1) triode
(2) tetrode
(3) diode
(4) pentode

b. PC 206-4 is a grounded _____ type amplifier.

(1) control grid
(2) plate
(3) cathode
(4) screen grid

c. Input is applied to the _____ grid.

(1) screen
(2) control
(3) suppressor

d. The _____ grid is grounded; the _____ grid is at a high D.C. Voltage.

(1) screen
(2) control
(3) suppressor

11. Energize the amplifier and adjust the grid bias (R17) and the input signal (from the signal generator) for maximum undistorted output.

12. What is the gain of the amplifier? _____.
The output is (in phase/180° out of phase) in respect to the input.

13. Disconnect the signal input to the amplifier. Using the 10X Probe, measure and record the following DC voltages:

a. B+ _____ VDC
b. Screen grid _____ VDC
c. Cathode _____ VDC
d. Control grid _____ VDC
e. Suppressor grid _____ VDC
f. Plate _____ VDC

14. The tube is (conducting/cut-off).

15. De-energize and return all equipment to its proper stowage.

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JOB PROGRAM
FOR
LESSON II

PART II

Operation of the TV-7D/U or TV-10D/U Tube Tester

INTRODUCTION

This job program will familiarize you with the operation of the tube tester and allow you to practice testing tubes with the equipment.

SAFETY NOTE:

Beware of getting burned by hot tubes! The filaments of the tube sometimes cause the glass envelopes to become extremely hot after test. Care should be taken in removing the tube from the tester.

REFERENCE(S)

1. Instruction Manual for TV-7D/U Tube Tester

EQUIPMENT REQUIRED

1. TV-7D/U or TV-10D/U Tube Tester
2. Box of practice tubes.

PROCEDURE

1. The operation of this tube tester is described in the following places.

   a. Audio Visual presentation 21 T-11.

   b. Instruction Manual located in the cover of the tube tester.

2. Familiarize yourself with the operation and location of the switches of the tube tester by using either one or both of the sources of information listed above.

3. Test the 5687 tube (if you have already tested this tube in the AV package, go on to step 4.)

4. Test the remainder of the tubes in the box. Use the answer sheet below.

ENSURE THAT YOU TEST EACH TUBE FOR SHORTS BEFORE CHECKING EMISSION. DO NOT PROCEED WITH THE REST OF THE CHECKS IF A SHORTED CONDITION EXISTS.

TUBE TYPE	SHORT	EMISSION	GAS	
5687				good/bad
				good/bad
				good/bad
				good/bad
				good/bad
				good/bad

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PROGRESS CHECK
LESSON 11

Vacuum Tube Circuit Configurations

1. A grounded-cathode tube configuration can be compared to a/an _____ transistor configuration.

2. Input signals to tube circuits are usually (smaller/larger) than the input signals to transistorized circuits.

3. The grounded-cathode configuration has

   a. good voltage gain and poor power gain.
   b. poor voltage gain and poor power gain.
   c. poor voltage gain and good power gain.
   d. good voltage gain and good power gain.

4. The grounded-grid tube configuration is comparable to the _____ transistor configuration.

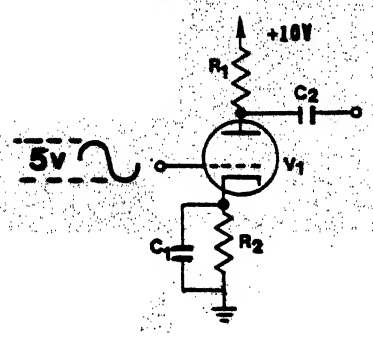
5. A grounded-grid circuit has a (smaller/larger) voltage gain than the grounded-cathode amplifier.

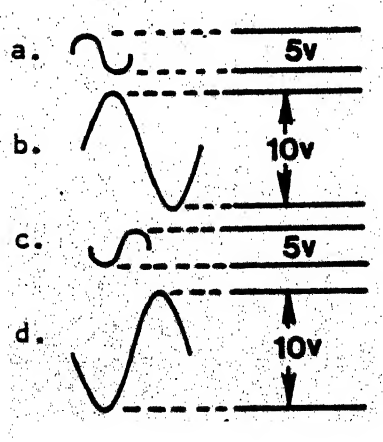
6. The cathode follower configuration is comparable to the _____ transistor configuration.

7. Push-pull circuits are used as

   a. power amplifiers.
   b. impedence amplifiers.
   c. input amplifiers.
   d. voltage regulators.

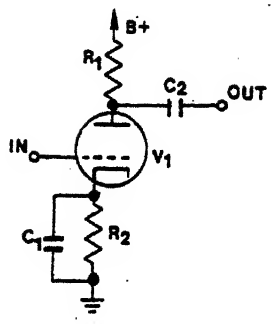
8. Which of the output signals shown below would you expect from a grounded-cathode circuit?



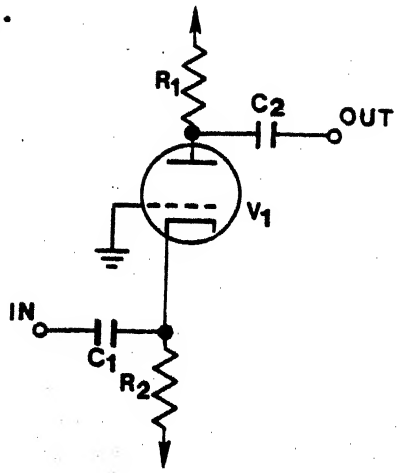


9. Label the types of tube configurations illustrated below:

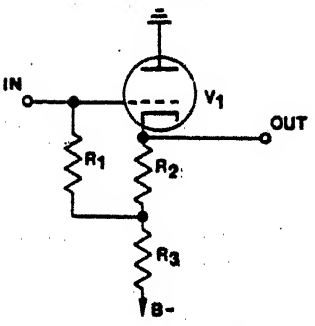
a.



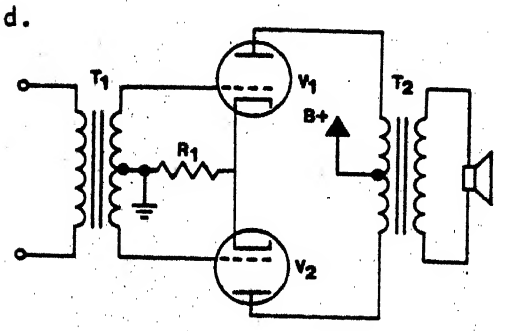
b.



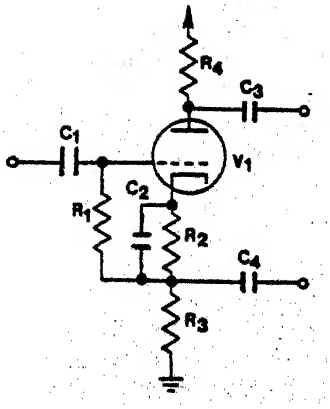
c.



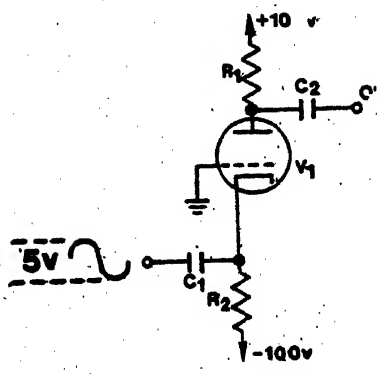
d.

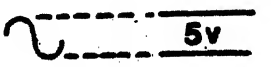


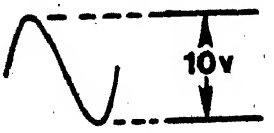
e.

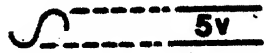


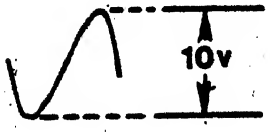
3. Which of the output signals illustrated below would you expect to see =om a grounded-grid amplifier?



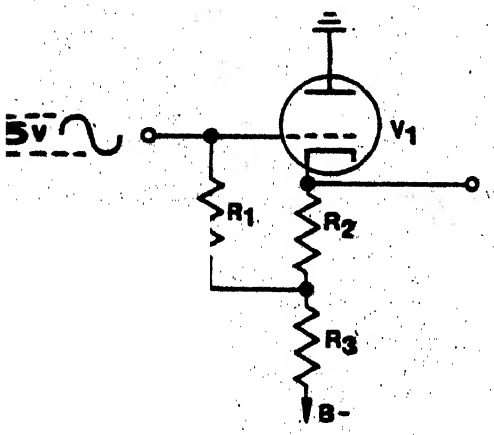
a. 

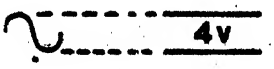
b. 

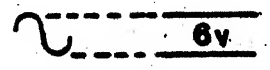
c. 

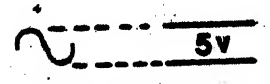
d. 

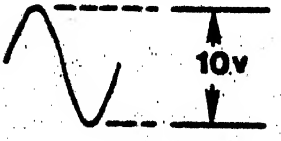
4. Which of the output signals illustrated below would you expect from a athode-follower?



a. 

b. 

c. 

d. 

HECK YOUR ANSWERS TO THIS PROGRESS CHECK WITH THE ANSWERS IN THE BACK OF OUR STUDENT GUIDE. IF YOU FEEL THAT YOU HAVE FAILED TO UNDERSTAND ANY ART OF THIS LESSON YOU SHOULD CONSULT YOUR LEARNING CENTER INSTRUCTOR FOR SSISTANCE AND REMEDIATION. IF YOU ANSWERED ALL QUESTIONS IN THE PROGRESS HECK CORRECTLY, CONSULT YOUR LCI FOR ASSIGNMENT TO THE MODULE TEST.

ANSWER SHEET
FOR
PROGRESS CHECKS
LESSON I

Multi Element Vacuum Tubes

QUESTION NO.	CORRECT ANSWER
1	Control grid
2	b
3	NPN
4	Negative
5	b
6a	Plate
6b	Screen grid
6c	Control grid
6d	Cathode
7	Screen grid
8a	Plate
8b	Suppressor grid
8c	Screen grid
8d	Control grid
8e	Cathode
9	c
10	b

ANSWER SHEET
FOR
JOB PROGRAM
LESSON 11
PART 1

Vacuum Tube Circuit Configurations

7a.

PC	GAIN
206-1	8
206-2	0.6
206-3	4

7b.

PC 206-1	Yes	Signal is 180° Out of Phase.
PC 206-2	No	Phase Shift 0°.
PC 206-3	No	Phase Shift 0°.

7c. 206-1 common emitter
206-2 common collector
206-3 common base

10a. (4) pentode.

10b. (3) cathode.

10c (2) control

10d. (3) suppressor, (1) screen. (in that order)

12. 1 VAC input; 20 VAC output; Gain 20; 180° out of phase.

13. a. 220 VDC
b. 100 VDC
c. 0 V
d. -1.4 VDC
e. 0 V
f. 56 VDC

14. conducting

ANSWER SHEET
FOR
JOB PROGRAM
LESSON T-11
Part 2

Operation of the TV-7D/U or TV-10D/U Tube Tester

THE ANSWER SHEET FOR THIS EXERCISE IS IN THE BOX OF TUBES TO BE TESTED.

ANSWER SHEET
FOR
PROGRESS CHECKS
LESSON 11

Vacuum Tube Circuit Configurations

QUESTION NO.	CORRECT ANSWER
1	Common emitter
2	Larger
3	d
4	Common base
5	Larger
6	Common collector
7	a
8	d
9a	Grounded-cathode
9b	Grounded-grid
9c	Cathode follower (grounded plate)
9d	Push-pull
9e	Phase-splitter
10	b
11	a

NOTES

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